MIT International Center for Air Transportation

Decision-Support for Enhancing Aviation Weather Information Systems and Safety

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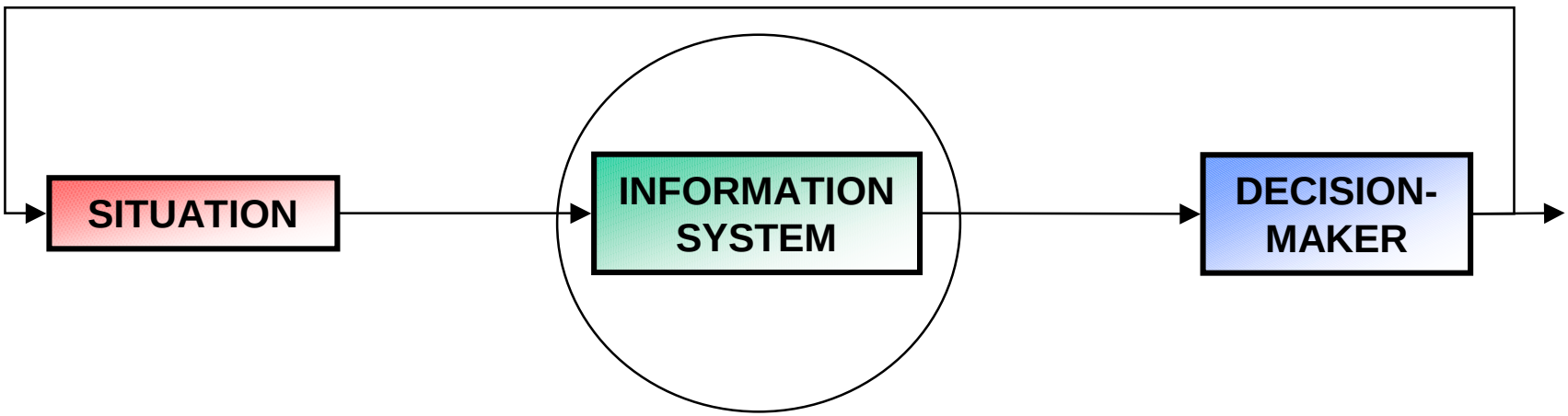
Overview



Objective: Enhance Information System

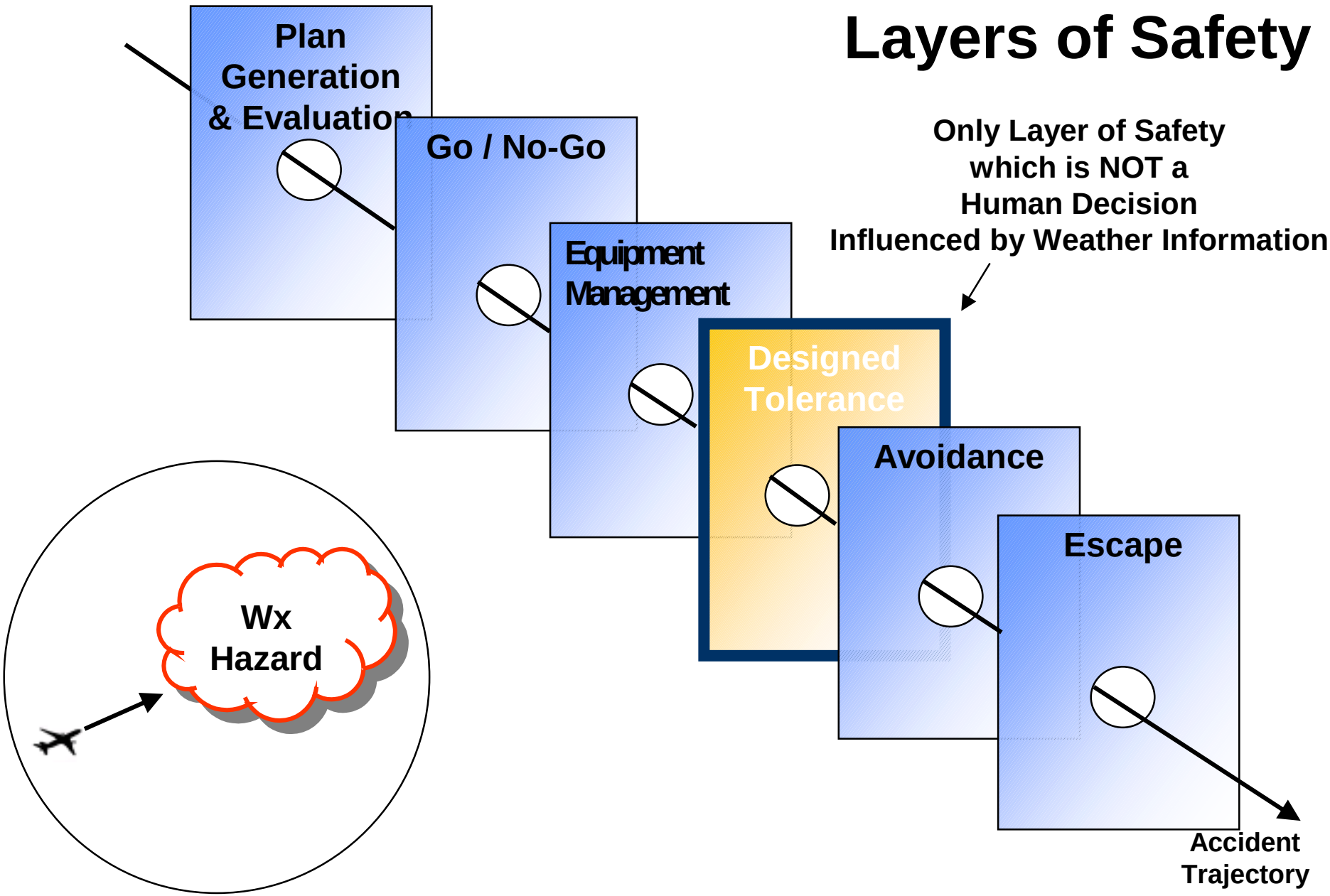
Approach: Study the Influence of Weather Information Predicated on Explicit Articulation of Avoidance & Escape Options on Pilot Decision-Making

Motivation

- **Aviation Weather**
  - Safety
    - Contributing Factor in Accidents
      (22.5% US Commercial Aviation, 72% Worldwide)
  - Efficiency
    - Major Source of Inefficiencies (Ground and Air Delays)
  - Economics
    - $1.35B (Accidents) + $2.1B (Inefficiencies)

- **Weather Information**
  - Opportunities with Deployment of New Technologies in CNS
    - Datalink, Weather Surveillance
  - Supports Front-Line Human Actor, Proven to Be
    - Source of Major Failure
    - Ultimate Barrier to Accidents
    - Maintainer of Performance in Degraded Situations

Weather-Related Decisions as Layers of Safety



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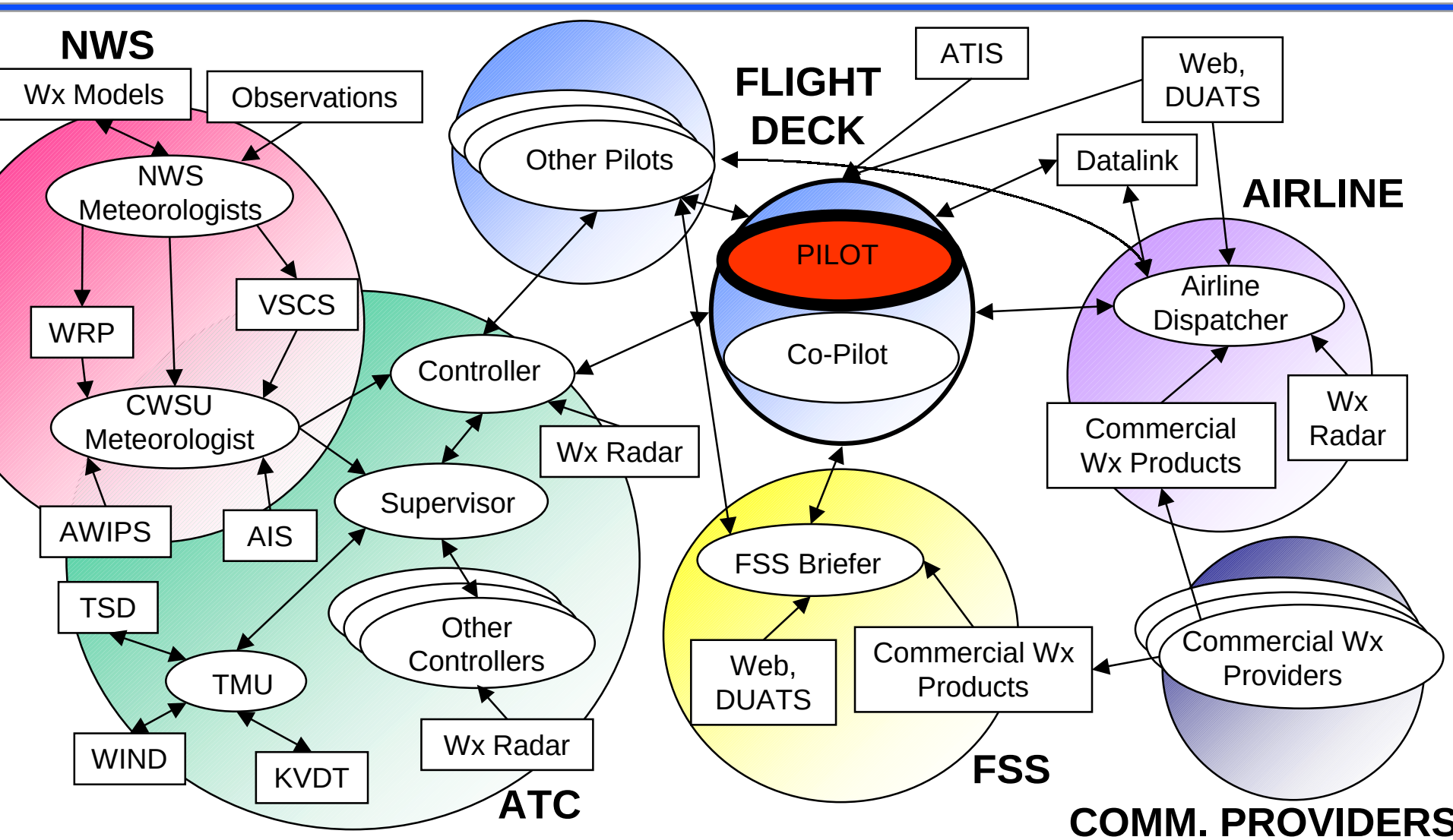
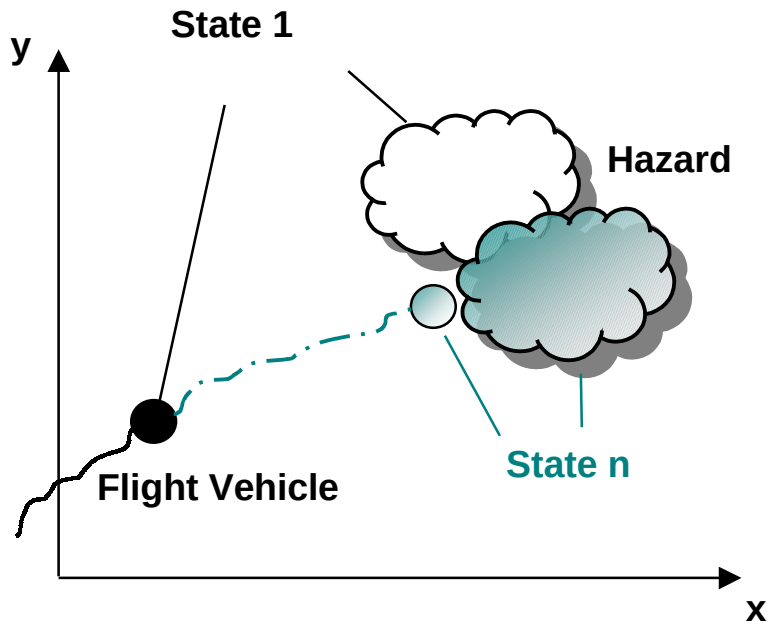
Weather Information Network (In Development)



Aviation Wx Abstraction



Flight Vehicle Hazard Encounter State Space Representation

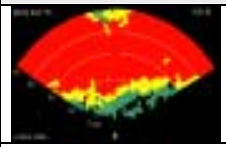
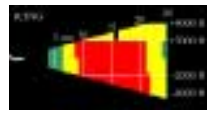
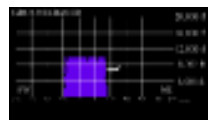
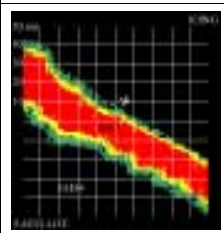
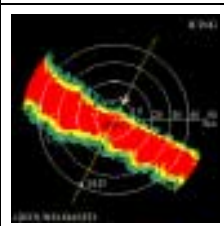
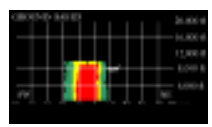
- **Adverse Wx Phenomena Characteristics**
  - Spatially Distributed & Bounded
  - Transient
  - Partially Non-Deterministic
  - Hazardous
- **Representation Issues**
  - 3D Information
    - Boundaries
  - Transient
    - Forecast
    - Ageing Information
  - Uncertain
    - Phenomena Description / Understanding
    - Impact / Severity on Flight Vehicle Operations
  - Partial
    - Volume / Area Coverage
    - Spatial Data Points
  - Involves Risk Assessment
- **E.g., Icing, Thunderstorms, Turbulence**

Problem Statement

- **Weather Information Can Take Multiple Forms**
  - Inform on Exposure to Hazard, or Risk [Certainty x Severity]?
  - Support Routing Optimization Based on Seeing and Avoiding Threat in Field?
  - Support Avoidance and Escape Evaluation?
- **Investigate Decision-Support Model Predicated on Escape Plan**
  - Value of Information About Non-Hazard Areas (Vigeant-Langlois & Hansman, 2000)
  - Value in Supporting Option-Based Decision-Making (Dershowitz, 1997)
  - Technically Easier to Detect Hazard-Free Space with High Confidence
  - If True, Can Pose “No-Safe-Escape” Avoidance Problem
  - Draw Analogy Between “Soft” and “Hard” Hazard Avoidance (Kuchar, 1995; Yang, 2000)

Icing Display Feature Matrix

Web-Based Study of 600 Pilots

Display	Name in Web-Based Experiment	Graphical Representation	Sensor Range [nm]	Vertical View	Type of Icing Info.
Display A	Textual Information	×	×	×	×
Display B (3D, min range, 3 levels)	Airborne Icing Severity System		25 (Min. Range)		Icing Severity 3 Levels
Display C (3D, max range, 1 levels)	Ground-based Icing Presence System		50 (Max. Range)		Icing Presence 1 Level
Display D (2D, max range, 3 levels)	Satellite-based Icing Severity System		50 (Max. Range)	×	Icing Severity 3 Levels
Display E (3D, max range, 3 levels)	Ground-based Icing Severity System		50 (Max. Range)		Icing Severity 3 Levels

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➢ Icing Severity vs. Icing Presence

- ⇨ No Significant Improvement in Decision Quality
  - ❑ Avoidance & Escape Decisions ↔ Information on Ice-Free Zones
- ⇨ More Direct Inference of Ice-Free Zones (T > 0°C or LWC = 0) than Icing Severity

Icing Products Based on Ice-Free Zones Easier and More Useful to Produce

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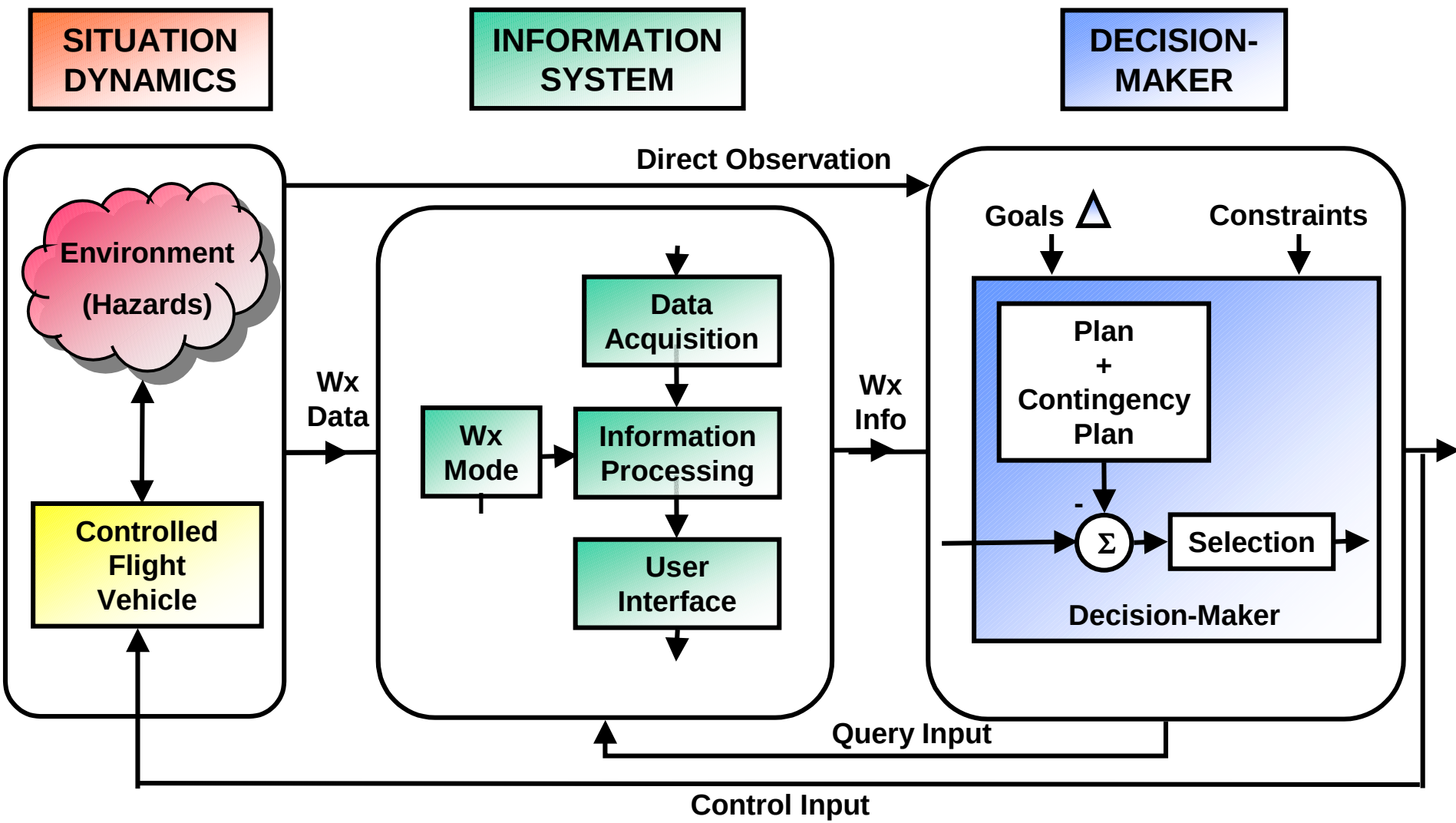
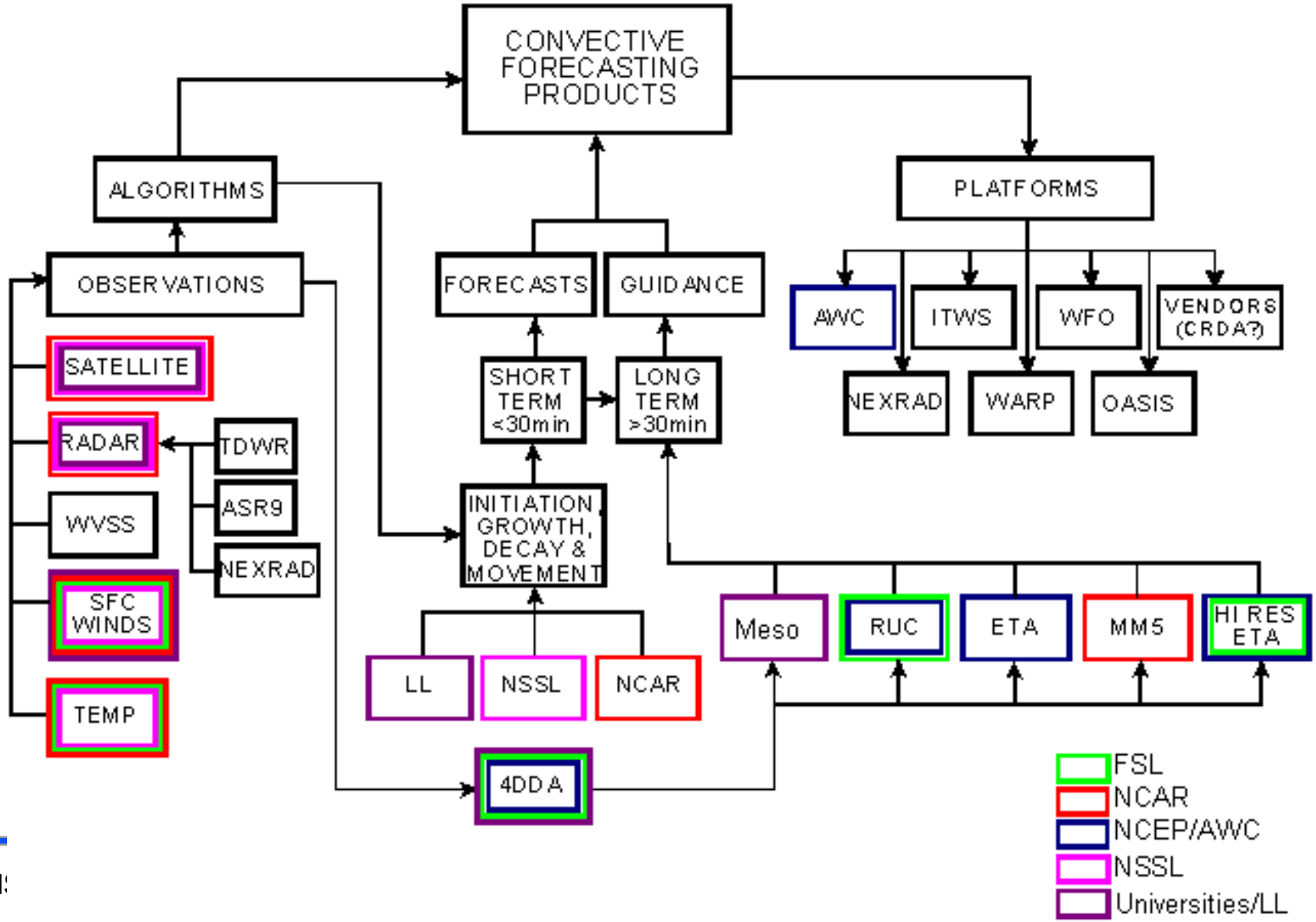
Weather Information System

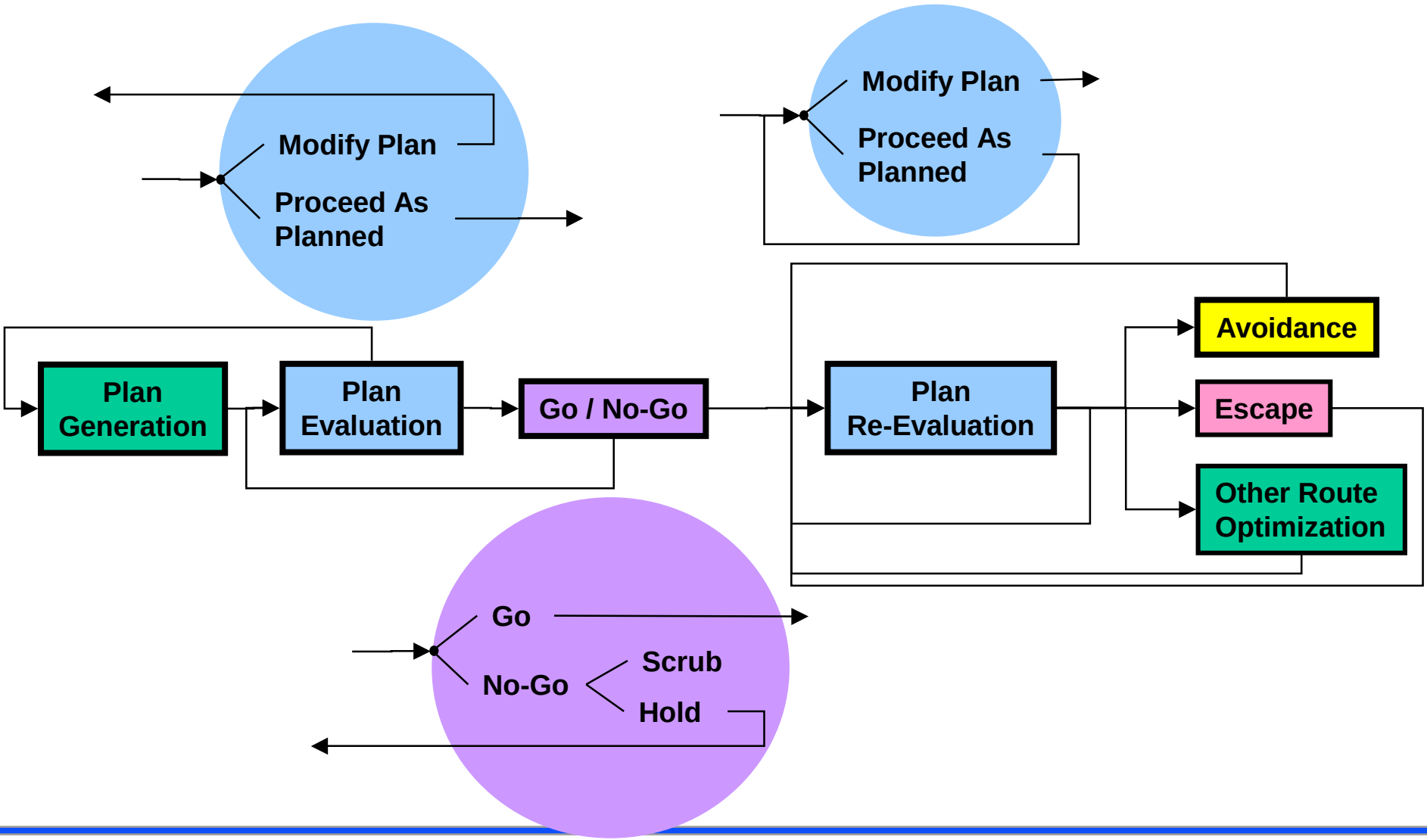
(In Development)



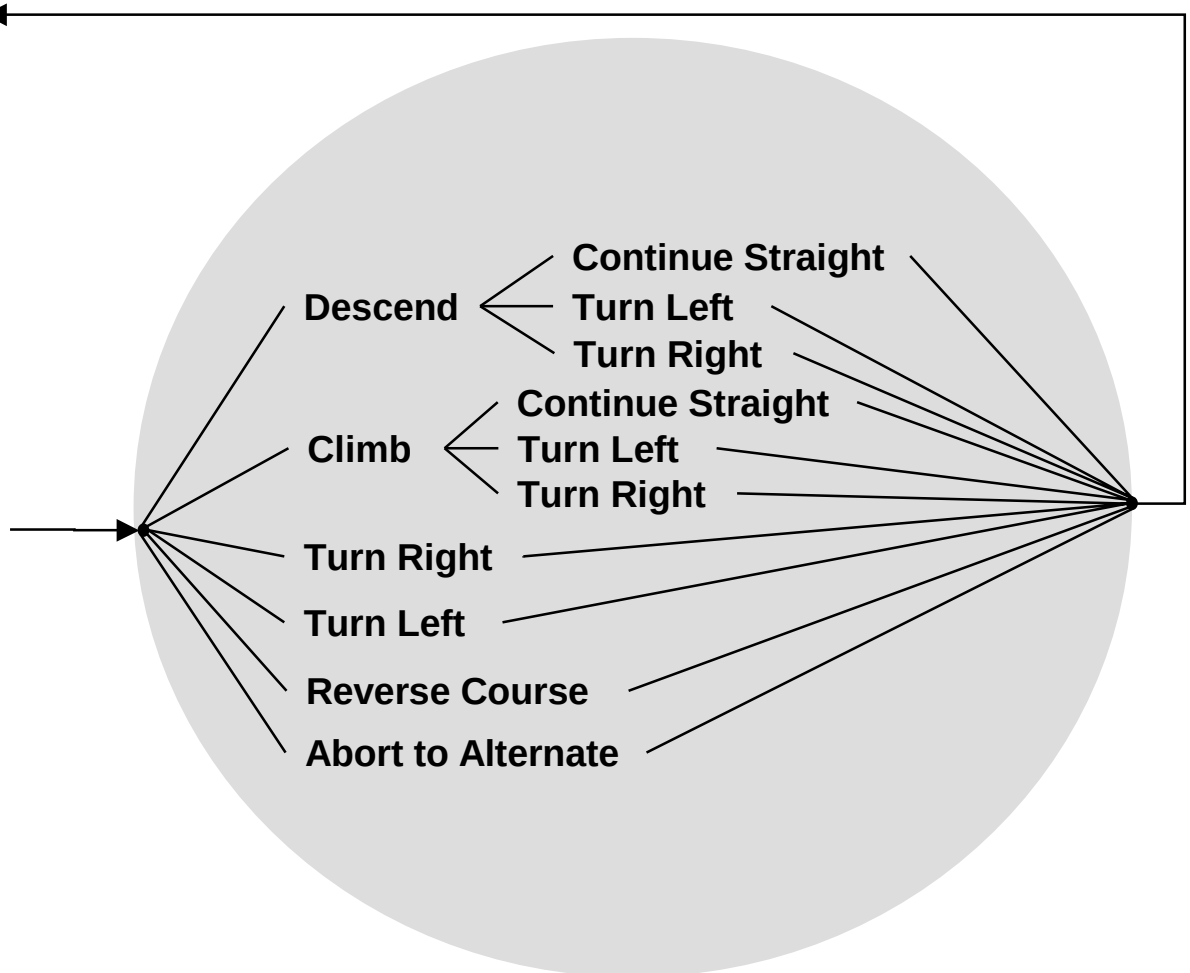
FAA Convective Wx PDT



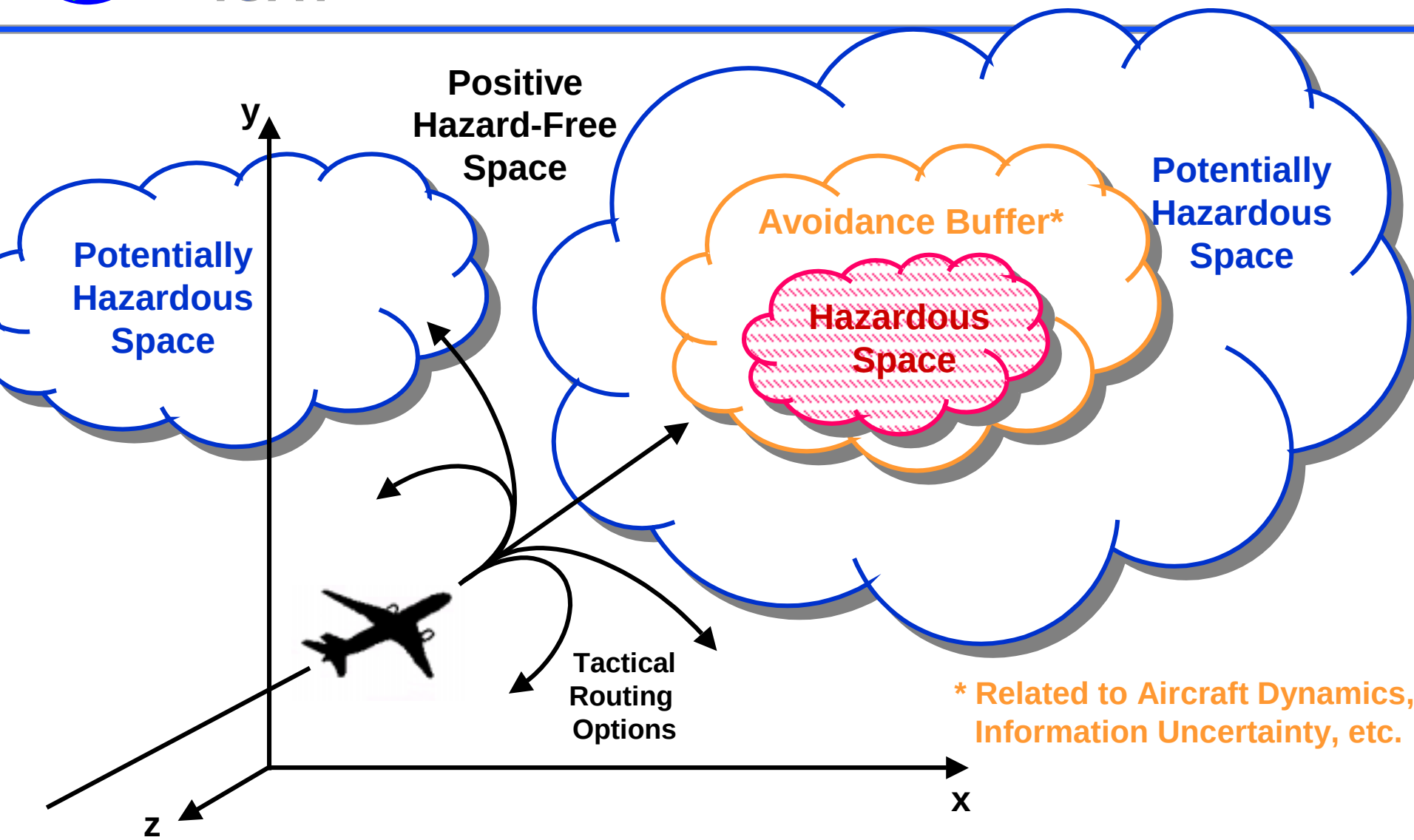
Decision Process Model
(Partial / Routing-Related)



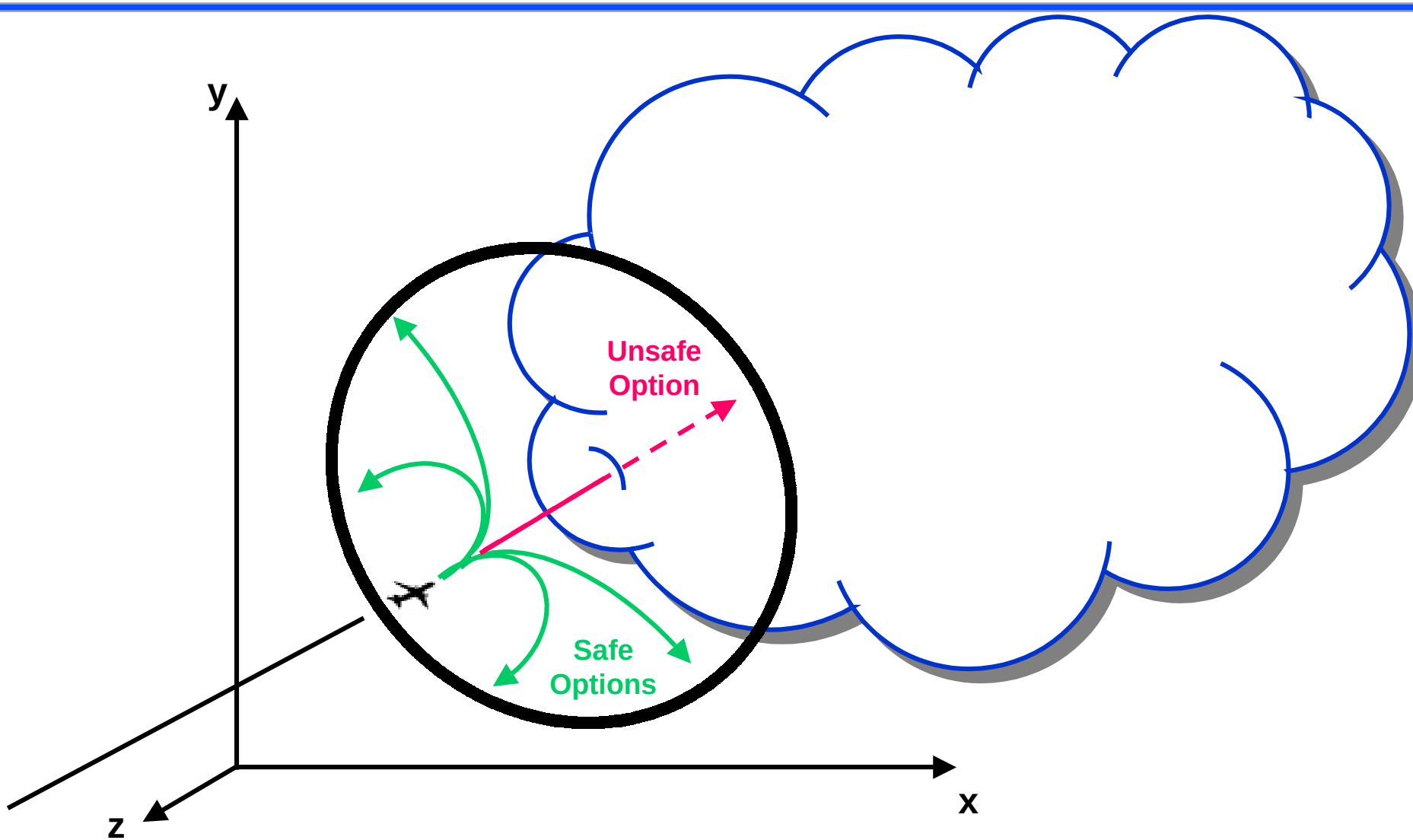
Avoidance/Escape /Other Route Optimization



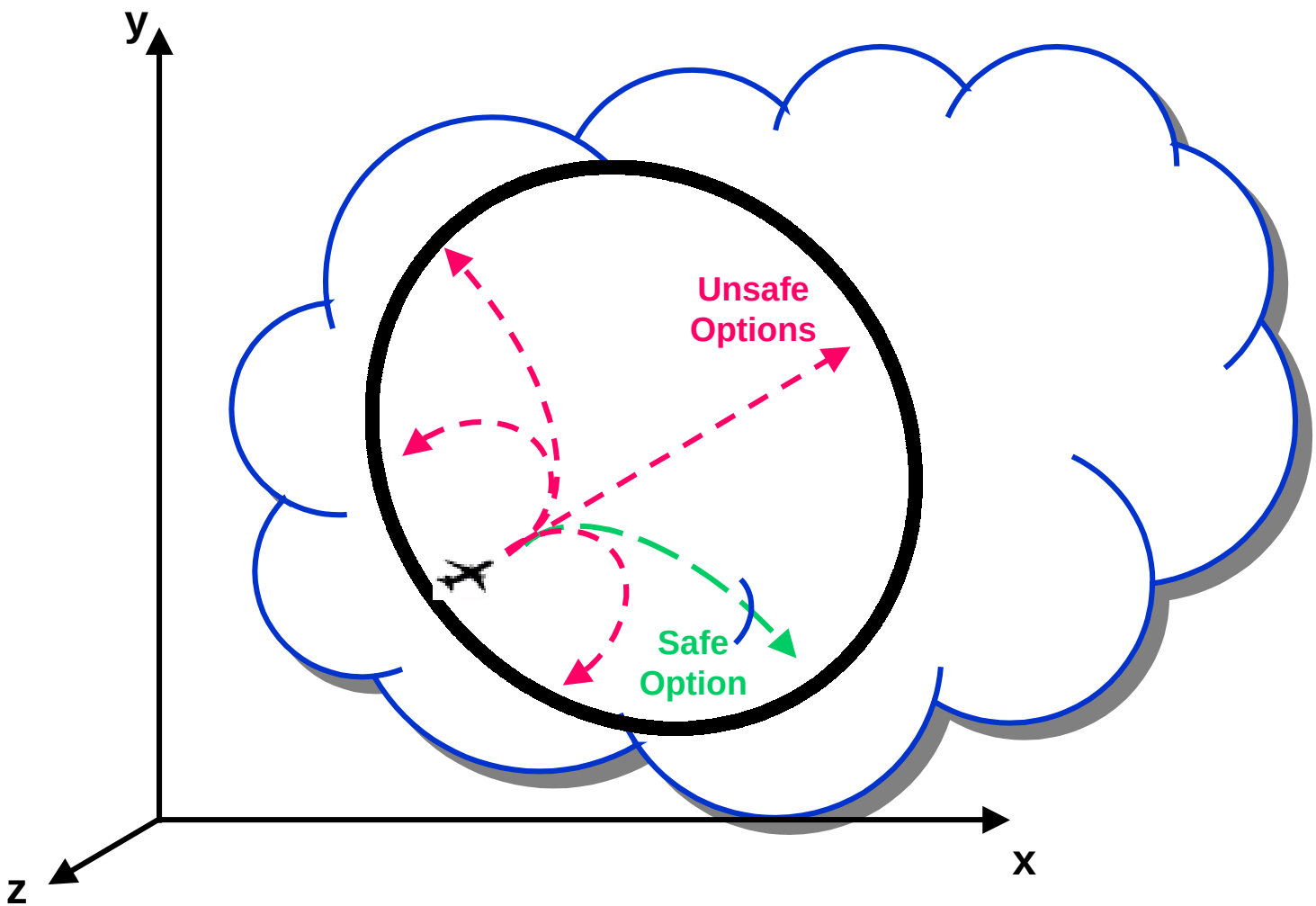
Hazard-Related Space



Tactical Avoidance



Tactical Escape



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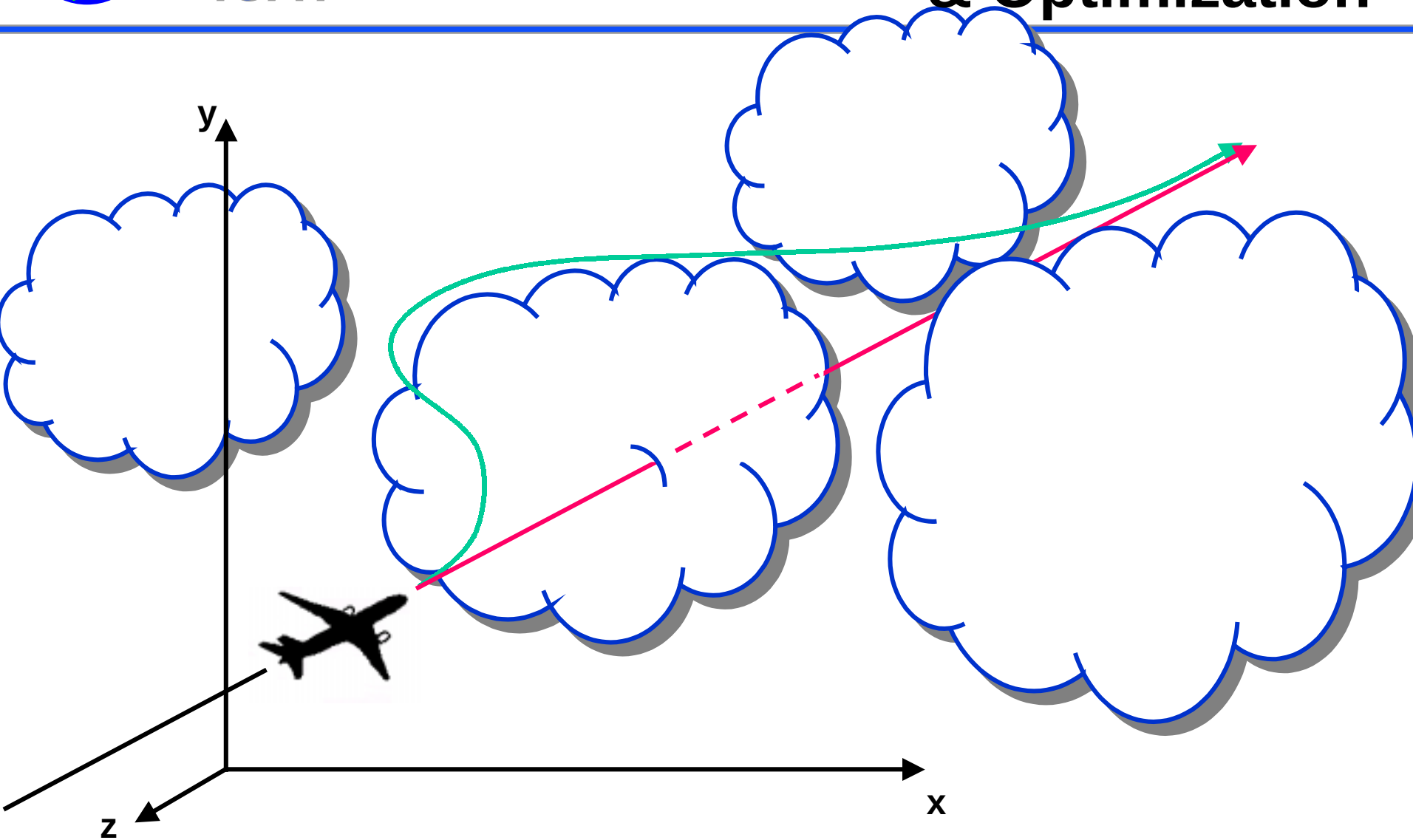
Strategic Avoidance & Optimization



Research Approach

- **Objective**
  - Study the Influence of Weather Information Predicated on Explicit Articulation of Avoidance & Escape on Pilot Option Selection
- **Proposed Work**
  - Refine Weather Info and Decision Models
  - Develop Prototype Displays to Support Avoidance and Escape Decisions
  - Evaluate Performance/Benefits of Prototype Displays
  - Make Recommendations
    - Weather Information System Architecture
    - Sensors
    - Displays
    - Dissemination

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